Camera Ab Initio Workshop

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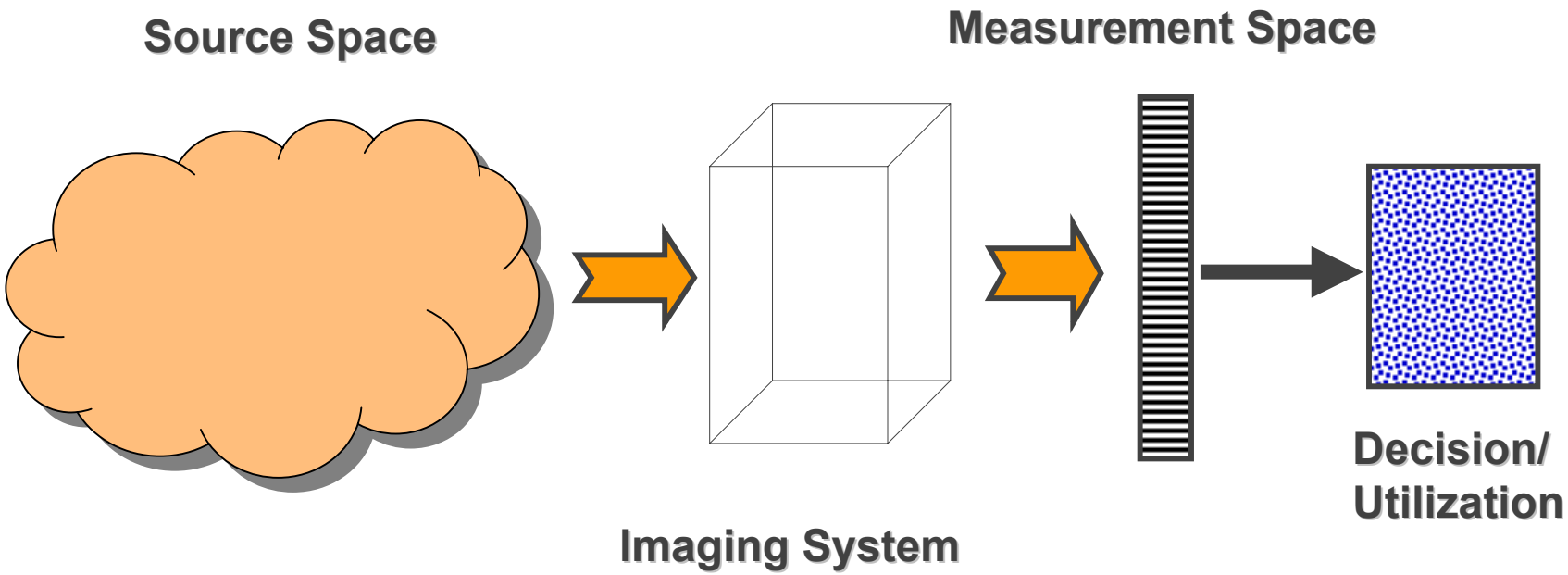
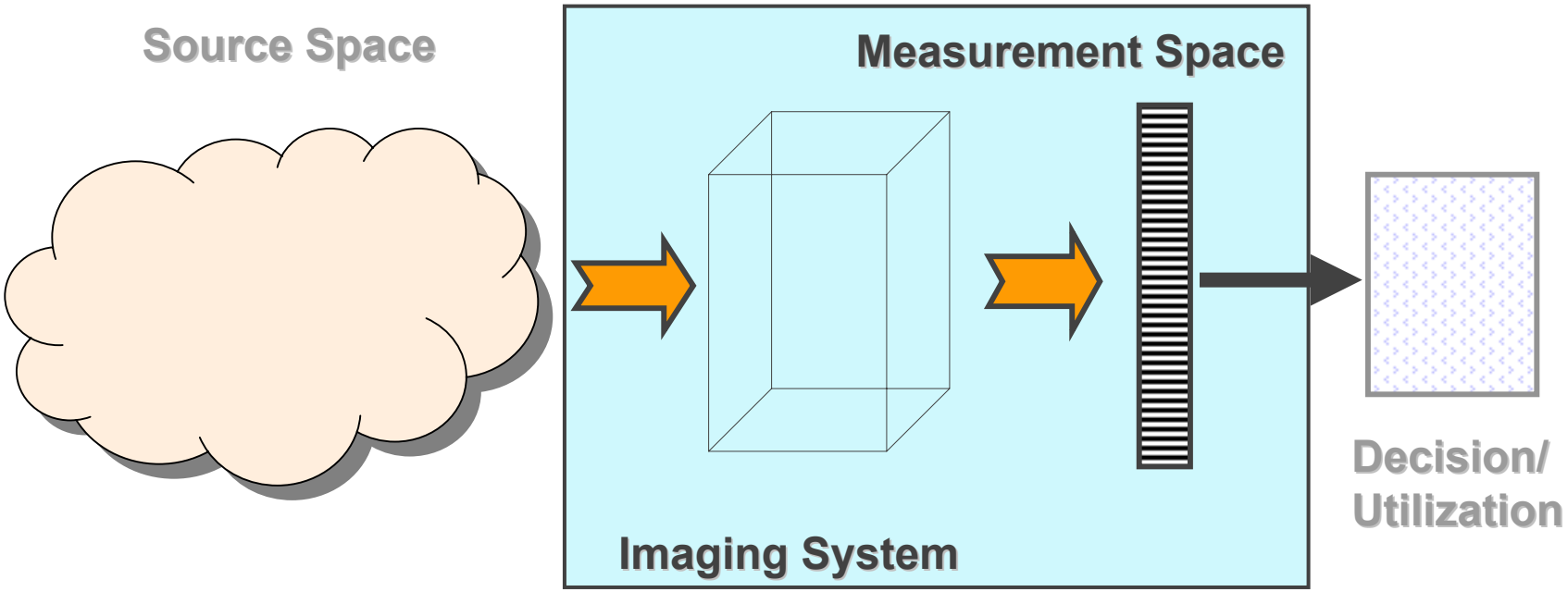
Definition of Imaging System



Information flow

Source state => EM field => Measurement => Decision/Utilization

Traditional Imaging Systems



Emphasis on producing a one-to-one mapping between the EM fields in the source space and the measurement space.

GOAL: **Making accurate measurements on increasingly finer spatial samples in the source space**

Data / Information Discrepancy

- Consider a hypothetical 3-D, hyperspectral, polarimetric imaging sensor:
  - 1000x1000x200(depth) Spatial resolution,
  - 200 spectral bands
  - 10 bit dynamic range
  - 3 polarization measurements

  Total data collected per frame: **150 Gbytes**

- Consider a hypothetical scene with 300 interesting targets to be identified, each target requiring 24 bits for complete characterization => **~ 1 kBytes of information**

The Other Extreme

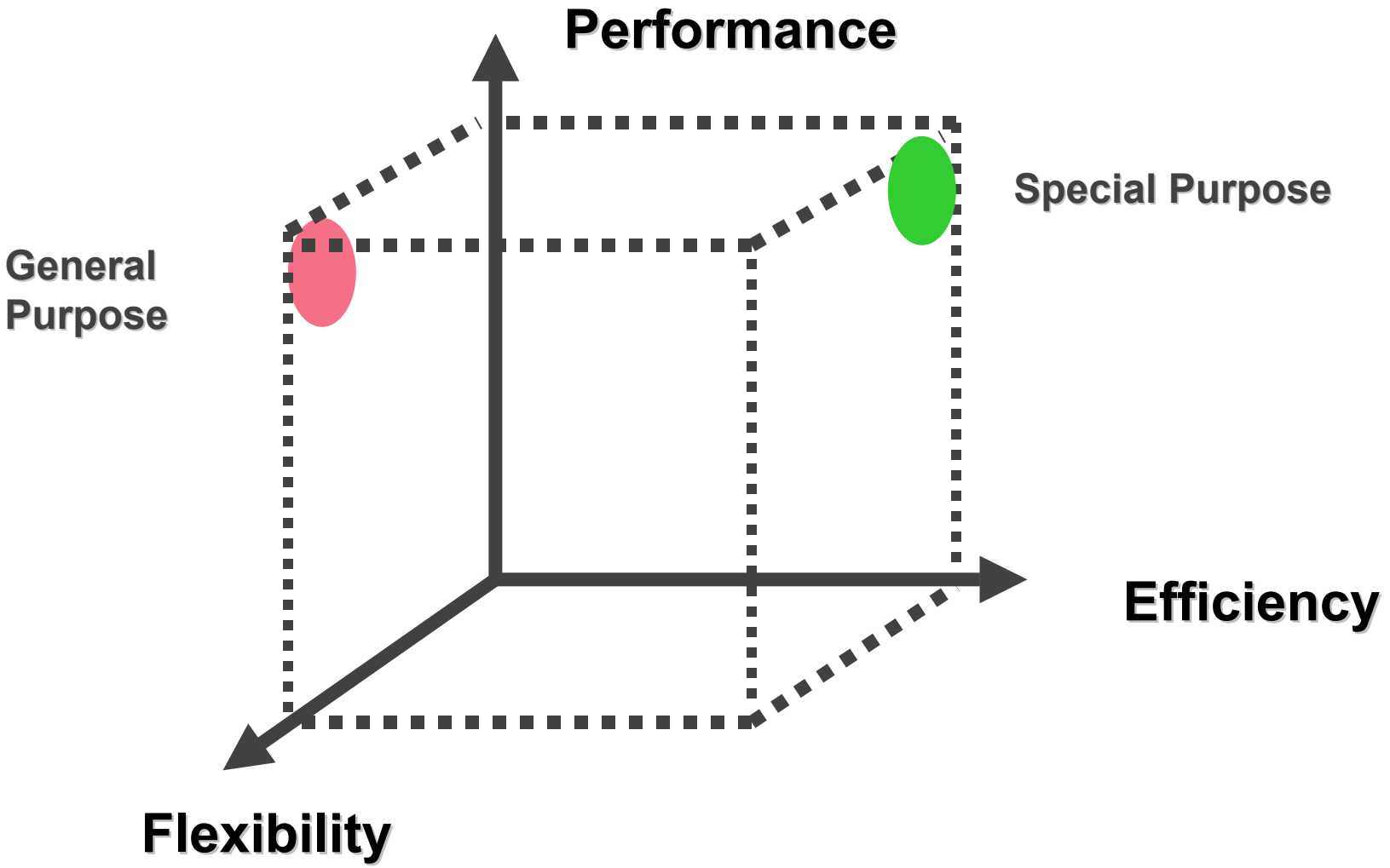
- Extremely simple “imaging” sensors that only collect global information about the source space:
  - Light level sensor: single channel, wide acceptance angle detector + single binary detection post processor
  - Motion sensor: single channel, wide acceptance angle detector + simple post processing circuitry
- There is a continuum between systems that ***MEASURE EVERYTHING*** and systems that ***MEASURE A SINGLE PARAMETER THAT MAPS DIRECTLY ONTO THE DECISION SPACE***.

Tradeoff Space

- Performance:
  - How well the system accomplishes the task which it is currently performing. Metrics are task specific.
- Flexibility:
  - How many different tasks can the system perform.
- Efficiency:
  - Indication of resources the system requires in order to deliver the desired level of performance.

    Resources: volume, time, energy, weight, mechanical complexity/fragility, cost……

Trade-off Space



Ideal System

- Problem Description:
  - Hard to detect mobile targets
  - Volume / weight / power / bandwidth limited platforms
  - Increasingly shortened timeline

- Approach:
  - Use full parameter space

    spatial, temporal, spectral, coherence, polarization…
  - Efficient use of photons
  - Efficient use of hardware (sensors, processors)
  - Inhomogeneous, time variant response in order to perform efficient resource allocation to different measurement spaces.

Summary

- Advanced sensors can generate *PRODIGIOUS* amount quantity of data
- The post processing and communication systems are overloaded
- Amount of information to be extracted in a typical scene is far smaller than the total data generated
- Joint optimization of pre-optics, sensors and post-processing algorithms/hardware should be explored
- Inhomogeneous, time varying allocation of system resources to different modalities and multiplexed sensing can provide the desired balance between performance, flexibility and efficiency.